The Integration of Natural Drainage in an Urban Subdivision

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Abstract

Subdivision design establishes the relationship between buildings and infrastructure. Yet infrastructure design is typically an afterthought to the site layout dictated by pre-existing standards. It's often hard to get plan approval for innovative approaches under a tight schedule. Seattle Housing Authority's (SHA) 120-acre High Point Redevelopment challenges this approach.

High Point totals approximately 8% of the Longfellow Creek watershed, providing an opportunity to improve water quality and stream flows to Longfellow Creek—a priority watershed with high Coho Salmon returns. Seattle Public Utilities' (SPU) proposal to integrate an innovative drainage system into this predominately townhouse style housing development was uncharted territory. Discussions, analysis and planning took approximately two years. SHA collaborated with the City of Seattle to achieve approval of the subdivision plan, including a natural drainage system, comprised of a network of swales, ponds and multi-functional open space, throughout the 34 blocks of right-of-way.

This difference from the usual design review process started by including City plan reviewers, SHA staff, the design team and technical experts in a design charette to negotiate the streetscape. This produced dialogue and increased understanding of other disciplines and interdepartmental issues. Charette participants recognized the need to focus on performance rather than standards to meet the goal of balancing community and ecological needs. Following the Charette, focus was on methods to incorporate the requirements to ease future permitting while maintaining City control for drainage management. After considerable discussion, drainage restrictions were included in the subdivision documents and future homeowner association covenants.

High Point provides guidelines for future construction of publicly and privately funded homes that encourage low impact development. Using a performance-based approach, the design meets the needs of the client, infrastructure stakeholders and ecological function. Most importantly, the High Point model challenges beliefs that dense urban design and ecological performance are mutually exclusive.

Introduction/Project Objective

In Seattle, the term "natural drainage system" is used to describe a category of drainage capital improvement projects that strive to meet multiple goals within street right-of-ways, which account for 25% of Seattle's total land surface. Natural Drainage System program goals include infiltration, flow attenuation, filtering and bio-remediation of pollutants by soils and plants, reduced impervious surface, increased vegetation, and related pedestrian amenities. These projects use natural features - open, vegetated swales, stormwater cascades, and small wetland ponds - to mimic the functions of nature lost to urbanization. At the heart of all Natural Drainage System projects are the plants and trees, and the deep, healthy soils that support them. All three combine to form a "living infrastructure" that, unlike pipes and vaults, increases in functional value over time. (Seattle Public Utilities - http://www.cityofseattle.net/util/NaturalSystems/overview.htm)

Seattle Public Utilities (SPU) is partnering with Seattle Housing Authority (SHA) to integrate a natural drainage system (NDS) into the High Point Redevelopment project (High Point). This project, financed in part with HUD Hope VI funding, is a 120-acre mixed income housing redevelopment located in the Longfellow Creek Watershed in West Seattle. One of the largest Seattle developments in recent history, High Point will create 34 blocks of new streets complete with new utilities, street trees, sidewalks, parks and open space. It will provide a total of 1,600 housing units plus a neighborhood center, library, and mixed-use block. This new urbanist development is unique within the built-out conditions of Seattle. SvR Design Company is the civil engineer for this project and the landscape architect for the right of way landscape, leading the design of the NDS at High Point.

Longfellow Creek Watershed located in West Seattle, is a waterway running south to north through developed city neighborhoods in West Seattle's Delridge valley. The watershed collects stormwater runoff from an area of approximately ~~2,685~~1,730 acres and eventually outfalls into Puget Sound. Longfellow Creek is a high-priority, salmon-bearing watershed and has been identified by "the community and the City as a significant and valuable

resource" (www.longfellowcreek.org). The area of High Point plays a "particularly important role in the City's environmental stewardship responsibilities" (11/5/02 Memorandum of Agreement) for the Longfellow Creek Watershed.

During the planning phase of High Point, the Seattle Housing Authority was approached by the City of Seattle Public Utilities (SPU) to partner and develop a Natural Drainage System (NDS) strategy for the project as part of the Integrated Drainage Plan required for permitting. The opportunity of developing a natural drainage approach in an existing large urban redevelopment project area was important to improving the protection of Longfellow Creek and as an example of what could be done to retrofit other City neighborhoods.

As part of the partnership, Seattle Public Utilities developed a Mission Statement for Seattle Housing Authority's High Point Community Revitalization plan:

"Support Seattle Housing Authority in integrating affordable housing, open space interests and critical creek habitat protection by developing and evaluating several natural drainage options for their ability to meet the interests of Seattle Housing Authority and the City of Seattle."

The partnership also agreed to work together on funding and the interdepartmental permitting process. The Seattle Public Utilities agreed to reimburse the Seattle Housing Authority for additional costs of the NDS approach. SHA would remain responsible for achieving "code compliance" but SPU would assist with the analysis, modeling and design of the NDS system. The subdivision design had already achieved a tight footprint with the new urbanist approach. This was not a typical large lot development but one where the total unit lot size including the building footprint was as small as 1200 square feet. The overall site plan was approximately 65% impervious. The City was asking SHA to go a step further and attempt to reduce the impervious area to 60% overall with the goal of increasing stormwater filtration for small storms at the block scale. SHA was still required to meet conveyance and major storm water discharge requirements necessitating the installations of the "traditional" storm drainage systems, i.e. conveyance pipe network and stormwater pond. The Natural Drainage System includes retention swales and porous pavement within the ROW and on-site drainage restrictions.

Project Methodology and Data

In developing the Natural Drainage System for the High Point project, the Seattle Housing Authority and Seattle Public Utilities looked to mitigation measures that could manage and treat the stormwater closer to its "source" while at the same time meeting the Seattle Housing Authority's goal of building an affordable housing community with a traditional in-city neighborhood feel. In other words, standard curb and gutters were a requirement in order to blend in with the adjacent older neighborhoods. Some of the stormwater mitigation measures include: allowing building roof drainage to sheet flow across a lawn and planting areas; amending the lawn and landscape areas to improve the absorption capability of the soil; developing filtration drainage swales to treat stormwater runoff from adjacent properties and streets; mitigating the allowable impervious and pervious areas for a site; and/or using porous paving materials.

The proposed drainage system approach for the main High Point Drainage sub basin includes an integrated network of both "natural drainage system" facilities, such as vegetated swales and conveyance swales, along with the traditional catch basin/inlet structures with storm drain conveyance pipes for the conveyance of large storm events. In addition, a stormwater detention pond at the northeast corner of the site has been designed and sized to provide flow control for the 2-year and 25 year storm events. The traditional drainage systems of pipes and detention were required when it was determined that on site soils even with amendments would not accommodate the larger flows.

Topography and Soils:

High Point is located on a 160 foot-high bluff overlooking the Delridge area of West Seattle. The site's eastern edge is comprised of a steeply sloped greenbelt identified by the City of Seattle as an Environmentally Critical Area (ECA). The Environmentally Critical Areas are not included in the redevelopment of the site. Currently, the on-site topography consists of alternating plateaus and cut-sloped areas that step down to the top of the ECA greenbelt. The average grade through the project site is approximately 5%. The total vertical relief from south to north is on the order of 150 feet.

A geotechnical evaluation of the site's soils, including field explorations, laboratory testing, tests for infiltration rates, and various other geotechnical engineering studies was conducted. In general, the evaluation concluded that the site is composed of the following surficial soils (upper existing 5 feet+/-):

- Glacial Till
- Silty Fine Sand/Fine Sandy Silt
- Gravelly Sand/Sandy Gravel
- Slightly Silty Fine to Medium Sand
- Peat/Organic Silt
- Fill (of varied components from previous construction development on the site)

However, while variability was found with the soils, in general, the site's soils can be characterized as primarily Silty Fine to Fine Sandy Silts. In addition, for the majority of the site, the assumed potential of subsurface infiltration/storage was rated as "poor". This resulted in the decision to "engineer" soils to achieve the desired hydraulic conductivity in the NDS swales rather than amend native soils.

Natural Drainage System Strategies:

The natural system design proposes to integrate 15,000 lineal feet of vegetated and grassy swales throughout the development within the right of way planting strip. These swales include sub-surface engineered soil to provide storage and infiltration opportunities. Each swale is designed to treat the runoff from the street and housing of the adjacent block. At a system scale, natural drainage systems will provide water quality treatment for the 6-month storm and attenuate the two-year, 24-hour storm to pre-developed pasture conditions. This distributed block-scale system provides much greater opportunity to cleanse, cool and infiltrate stormwater runoff than the traditional piped and centralized management approach. The design team developed a block-scale continuous hydrologic model to refine the design performance and predict how the system will perform under different storm events. SPU will be working with the University of Washington to monitor the performance of the built system at the block and sub-basin scale. (Seattle Public Utilities)

Delineation of the Natural Drainage System Swales within the Public Right-of-Way:

Assumptions for the location, length and cross-section of the NDS swales within the public right-of-way were based upon discussions with Seattle Housing Authority, its design consultants and the Seattle Public Utilities and its consultants.

Location: The location for the NDS facilities was based on a two-step process:

Delineate which side of the street the swale would be located:

1. Based on the housing concept plan from Mithun Architects and topography, the swales were located on the side of the street with the least amount of driveway crossings and existing street trees to be saved.
2. Delineate the location for each swale type: shallow grass-lined and deeper vegetated. Since the NDS swales would be located within the planter strip of the street right-of-way, the ability for pedestrians to easily cross the planter strip to reach their parked vehicles was a primary criterion that determined the location of shallow grass-lined and deeper vegetated swales.

Site Design:

Site design strategies were also required in order to meet the 60% impervious goal for the townhouse type of housing. At the planning level this appeared very doable but as the design worked through programming the overhangs, patios, walks, driveways, storage sheds and mailbox zones it became apparent that more aggressive strategies would be required.

- The Plat- the City was concerned about the ability through current City regulations to restrict development beyond the zoning. This resulted in applying restrictions to properties at the parent lot level that were recorded with the plat. These restrictions cover impervious area, drainage connection points and requirements to disperse roof drainage on-site.
- Site design- Design modifications were required to keep individual parcels within the plat requirements. These primarily impacted the percent of impervious surface and required revisions to accommodate porous pavements.
- Site permitting - Permitting reviews were a concern with the City. The City did not believe their current review process could accommodate the review of design strategies to address natural drainage. Initially, it was thought that "guidelines" would be sufficient however, as discussions progressed, it was apparent that a much tighter set of guidelines would be required that is now called the Site Drainage Technical Standards for the High Point

Community. This 75 page document will allow reviewers to work from a set of approved standards as well as give builders some certainty in the process.

Planning:

A considerable amount of time from the planning through the design phase has been spent on terminology. The semantics of High Point drainage design have caused iterative discussions on the meaning of disperse, porous, infiltrate, pervious, absorb, discharge, convey, trench, swale, perforated, gravel, filtration etc. Words become important as they mean different things to engineers, landscape architects, architects, regulatory staff, contractors, owners, developers, builders and real estate agents. Meanings or interpretations are not minor considerations when they affect bid prices and property values.

The Natural Drainage System approach at High Point required requirements and standards specific to High Point in order to convey the intent of the development. The desire to ensure the development will follow the intended approach and the need to explain the criteria and provide options for development resulted in five levels of commitment. The first was to take the unusual step of adding drainage thresholds in the Plat. The second was to develop a “Drainage Covenant” for the Plat of High Point Community. The third was to develop technical standards for compliance with the Drainage Covenant. These standards have evolved from the originally envisioned design guidelines to an approach facilitating permitting and implementation. The fourth level was the development of a Covenant for Maintenance of Natural Drainage Landscape, Open Space and Rights of Way for the High Point Community. This association involves all properties within the Plat of High Point Community and includes authority for fee assessment, maintenance and enforcement of common areas including the natural drainage landscape. The fifth level is the Memorandum of Agreement (MOA) between the City of Seattle and the Seattle Housing Authority regarding funding and maintenance of the drainage system.

The High Point Natural Drainage System began as a partnership between two public entities interested in redevelopment that addressed community needs for affordable housing and a pedestrian friendly neighborhood that incorporated progressive infrastructure. At times the partners had different priorities since the Seattle Housing Authority's primary commitment is to housing and community building and the Seattle Public Utilities primary goal was downstream water quality.

Many city departments became involved in the High Point natural drainage approach since in one way or another the design criteria and space needs impacted all of them. Although there was an undercurrent of "we are being compromised for drainage" the discussions were valuable in getting interdepartmental understanding of each other's requirements. The Seattle Housing Authority remained committed to trying this new approach and continually thought of ways to use the drainage design to spearhead community building. This type of commitment was crucial in keeping all parties focused on the long-term goal while intermediate hurdles popped up.

Plat:

Restricting the plat was not something SHA, the surveyor's or the land-use attorney wanted to do. The implications to the Plat as well as the Building and Site Permitting were not part of early discussions. These restrictions came about primarily due to City concerns on their ability to control the site development after the initial project was built and the future remodeling projects came in for permit. Now the City has decided to enter the permit data into their GIS for long-term tracking.

Design:

Site design at the parcel level is important to facilitate a natural approach to site drainage. High Point was well into the site layout for about half of the site while the natural drainage approach was being developed and refined. The "restrictions" or site drainage technical standards required rethinking the grading and paving approach in order to meet the requirements. A housing layout designed with the drainage in mind will facilitate future development. We also found that accessible units requiring flat parking and access areas made drainage more difficult. Finally since this was a mature site there was a goal to retain many of the significant trees. Maintaining the grades around the trees often worked against the natural pattern of drainage.

Permitting:

The various levels of permitting for a major redevelopment allowed opportunity to take advantage of this alternative approach. However while it was initially thought that partnering on drainage might simplify the overall permitting in the end it was more complicated. The success is that two public agencies continued to work through differences and constraints to achieve the bigger goal of an example of a sustainable urban community.

Construction:

An early goal was to develop an affordable approach to natural drainage that could be implemented in other City neighborhoods. As the design progressed it was a tough challenge to avoid engineering design criteria driving up construction costs. The second area of concern was frightening away bidders due to the unusual drainage approach and high level of attention to the project. The team attempted to describe the work with routine construction materials and terminology in order to minimize the cost impact of doing something different.

Since this is the first large scale approach to natural drainage systems in the City of Seattle, there will be a higher level of City oversight than a typical project. The contractors will be required to protect the natural drainage zones and the porous pavement from both traffic and adjacent drainage until sites are stabilized. Successful and very competitive bid for Phase I were opened in May 2004. Phase I ROW Cconstruction started in June of 2004 and is expected to be completed by end of 2005.

Market:

A major concern to SHA was how the real estate community would view potential for development and home sales with this natural drainage approach. The site has major advantage of in-city location and incredible views however how the drainage restrictions would be interpreted and affect property sales was a concern. The focus on simplicity and certainty of permitting appears to have paid off with a high level of interest from a wide range of builders.

Conclusions

One of the goals of the High Point Natural Drainage System was to develop design solutions that can be used in other urban retrofit locations. Developing an approved set of technical standards for residential scale development was an unexpected achievement. The design as well as the planning level model will be field-monitored for several years. It is hoped that lessons learned from Phase I construction will be available to incorporate into the design of the second phase of High Point as well as other City locations.

References

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Mithun Architects, March 2002, *Housing Concept Plan / Master Use Permit (MUP)*

Shannon and Wilson, Inc., February/March, 2004, *Geotechnical Engineering Report High Point Hope VI Redevelopment*

SvR Design Company, May/June 2004, *High Point Community Site Drainage Technical Standards May/June 2004*

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Hydrologic Modeling of Natural Drainage System for High Point Revitalization

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Hydrologic modeling was performed to evaluate the expected performance of a Natural Drainage System (NDS) for the High Point Revitalization project in Seattle, WA. The High Point Revitalization covers approximately 120 acres in West Seattle (Seattle, WA), which represents approximately 10% of the Longfellow Creek watershed. The completed development will include a mixed-income community with numerous public amenities, including trails, a public library, a health clinic, and shopping. The primary objectives of the study were to evaluate compliance with stormwater performance goals, cost effectiveness, and design optimization for NDS.

Key elements of the NDS include bioretention and conveyance swales that are distributed across the site within the public rights-of-way, rooftop runoff that is disconnected from the storm drain system, and extensive use of compost amended soils. These progressive techniques emulate natural hydrologic processes by promoting stormwater infiltration across the site. They provide a more effective approach to stormwater management than conventional stormwater practices, which typically rely solely on pipe conveyance and downstream detention ponds to meet stormwater regulations.

Hydrologic modeling of NDS is challenging, since existing models are not typically geared to examine the microscopic dynamics of bioretention swales and their complex interaction with other stormwater management practices, such as rooftop disconnects and lawns amended with compost soil, within such a large basin. Modeling techniques were developed for this study to examine the detailed performance of the bioretention swales at the city block- scale, as well as the cumulative performance of all elements of the NDS strategy for the entire High Point site. Hydrologic modeling was performed primarily using Hydrologic Simulation Program – FORTRAN (HSPF) to simulate rainfall runoff for the entire drainage area, including surfaces such as rooftops draining to compost amended lawns, rooftops draining to conveyance pipes, streets, sidewalks, and pervious land surfaces with various soils and slopes. Since HSPF does not perform coupled surface water/groundwater modeling, additional modeling was performed in MODRET groundwater modeling software to better represent the relationship between soil moisture storage and exfiltration for the NDS bioretention swales. Information obtained from the MODRET modeling was integrated into the HSPF model, so that the large-scale basin modeling could be coupled with more detailed physics associated with the NDS.